THE JOURNAL OF PHILOSOPHY
VOLUME LXXVIII, NO. 7, JULY 1981

SCENES AND OTHER SITUATIONS*

The truth is that man's capacity for symbol mongering in general and language in particular is so intimately part and parcel of his being human, of his perceiving and knowing, of his very consciousness itself, that it is all but impossible for him to focus on the magic prism through which he sees everything else.

Walker Percy[1]

MODEL-THEORETIC semantics is an attempt to use mathematics as a vantage point from which to focus on the most fascinating aspect of the magic prism, namely, how it is that sounds and marks can sometimes mean something. Surely we will never completely solve the mystery of man's capacity for symbol mongering, but the study of semantics can systematize our implicit understanding of human language and make clear where some of the mysteries lie. At least this is my hope.

Our knowledge of and beliefs about the world stem from our perceptions of the parts of the world with which we come in contact. In particular, our knowledge of our native tongue comes from experience and hence rests on perception. What is not quite so obvious—part of what Percy reminds us of—is that characteristically human perception in turn depends on language. Human language and perception are inextricable. Just how much so is

* The work in this paper grew out of logic seminars presented in the mathematics department of the University of Wisconsin and the philosophy department of Stanford University over the past couple of years. I greatly appreciate the interest and suggestions made by members of these seminars. I also wish to thank the following for comments on earlier written versions of this work: Robin Cooper, Dagfinn Føllesdal, W. V. Quine, Ivan Sag, and, especially, John Perry.

[1] *The Message in the Bottle* (New York: Farrar, Straus and Giroux, 1975), p. 26. Reading "The Delta Factor" and other essays in this book played a significant role in my decision to work on the model theory of natural language, for while reading this book I came to see some problems in the philosophy of mathematics which were puzzling me as special cases of important problems about language.

0022-362X/81/7807/0369$01.80

brought home to us from an unexpected source, the autobiography of the blind and deaf Helen Keller.[2] She describes a childhood walk with her teacher, Miss Sullivan, on a summer morning in 1887:

> We walked down the path to the well-house, attracted by the fragrance of the honeysuckle with which it was covered. Someone was drawing water and my teacher placed my hand under the spout. As the cool stream gushed over one hand, she spelled into the other the word water, first slowly then rapidly. I stood still, my whole attention fixed upon the motion of her fingers. Suddenly I felt a misty consciousness as of something forgotten—a thrill of returning thought; and somehow the mystery of language was revealed to me. I knew then that "w-a-t-e-r" meant the wonderful cool something that was flowing over my hand. That living word awakened my soul, gave it light, hope, joy, set it free! There were barriers still, it is true, but barriers that could in time be swept away.
>
> I left the well-house eager to learn. Everything had a name, and each name gave birth to a new thought. As we returned to the house every object which I touched seemed to quiver with life. That was because I saw everything with the strange, new sight that had come to me (34).

It seems to me that there is an important truth here. Before this experience Helen was able to *use* symbols, say to ask for water by spelling out "w-a-t-e-r." In this she was much like the behaviorist's animal or the computer scientist's Turing machine. But it was only with this step via perception into semantics, to understanding that the word meant water, that "the mystery of language" was revealed to her. She became a human language user in the true sense of the word.

In his essay "The Delta Factor," from which the quotes above are taken, Walker Percy uses Helen's experience as the starting point for an eloquent discussion of the place of human language in the human condition. I wish to use it as a starting point for a reexamination of some of the most basic assumptions of model-theoretic semantics. For, if Percy is right, if language and perception are inextricably linked, then the study of perceptual reports should be a rewarding area for research in semantics.

Previous work on the semantics of perception verbs (*sees, hears,* etc.) has placed them among the verbs of propositional attitude (*knows, doubts, believes,* etc.) and has made a valiant effort to account for the semantic facts within the traditional "possible worlds" semantics. But although the "possible worlds" approach has been reasonably successful in dealing with many of the seman-

[2] *The Story of My Life* (New York: Doubleday, 1954).

tic puzzles of knowledge and belief, it suffers from several well-known defects (logical omniscience,[3] for example) and seems to some of us to rest on dubious metaphysical and epistemological assumptions. In reading the papers of Jaakko Hintikka, Richmond Thomason, and Ilkka Niiniluoto on perception, it seemed to me that these defects and assumptions became intolerable.[4] With perception we are closer to direct experience than with the traditional verbs of propositional attitude, and our intuitions about the semantics are much clearer, but to square with these intuitions the model-theoretic machinery became quite bizarre. Furthermore, the approach does not provide an analysis of an important class of perceptual reports (what the linguist calls "naked infinitive" reports), those like (1) as opposed to (2):

(1) Austin saw a man get shaved in Oxford.
(2) Austin saw that a man got shaved in Oxford.

as I will show.

The feeling that something was radically wrong with the possible-worlds approach to the semantics of perception, coupled with the conviction that we all know, at some intuitive level, what it means for (1) or (2) to be true, led me to make a fresh start on the semantics of perceptual reports.

I secretly hoped that, in making this fresh start, I would eventually be able to improve the existing theory of semantics for verbs of propositional attitude. This has turned out to be the case. By combining his work on the semantics of belief with mine on perception, John Perry and I have developed a new approach to semantics, which we call *situation semantics,* to the point where we see it as a viable alternative to possible-worlds semantics.[5]

This paper only hints at the technical details of situation semantics. It is rather the story of my own transition from looking at

[3] The problem is that the theory cannot distinguish between logically equivalent sentences: it is committed to the claim that if you know, believe, or doubt ϕ, then you also know, believe, or doubt every logically equivalent ψ.

[4] I refer here to Hintikka's papers "The Logic of Perception" in *Models for Modalities* (Boston: Reidel, 1969), pp. 151-183, and "Information, Causality, and the Logic of Perception" in his *Intentions of Intentionality* (Boston: Reidel, 1975), pp. 59-75; to Thomason's "Perception and Individuation" in M. K. Munitz, ed., *Logic and Ontology* (New York: NYU Press, 1973), pp. 261-285; and to Niiniluoto's "Knowing that One Sees" in E. Saarinen *et al.*, eds., *Essays in Honour of Jaakko Hintikka* (Boston: Reidel, 1979), pp. 249-282.

[5] See our "Semantic Innocence and Uncompromising Situations," in P. A. French, T. E. Uehling and H. K. Wettstein, eds., *Midwest Studies in Philosophy* VI (Minneapolis: Univ. of Minnesota Press, 1981), pp. 387-404, and our forthexisting book *Situation Semantics.*

model theory for natural language in the tradition of Frege, Tarski, Davidson, and Montague (where the primary aim is to spell out the truth conditions of a sentence) to a model theory more in accord with the ideas of Austin and (late) Russell, a theory in which sentences describe types of situations in the world, with truth an important but derivative notion.[6]

This paper is organized as follows. In section I, I discuss the distinction between epistemically neutral and epistemically positive perceptual reports, a distinction borrowed from Fred Dretske, which is central to the argument of this paper. I then relate the epistemically neutral reports to the syntactically defined class of NI (naked infinitive) perception sentences discussed in the linguistics literature. This paper is devoted to an informal account of the semantics of NI perception sentences and with the consequences of this account for semantics in general.

Section II discusses the logic of NI perception sentences. In this paper I use the term 'logic' in a pre-theoretical, or informal, sense. For example, the inference

All men are mortal.
Socrates is a man.
⊢ Socrates is mortal.

is judged valid by any competent user of English—if both hypotheses are true, so is the conclusion. It is judged valid because of what the sentences mean, not because it can be translated into a formal argument in this or that formal system of logical inference. Formal accounts of logic have to square with such judgments, not vice versa. Thus, the judgments about the logic of NI perception sentences presented in section II constitute empirical evidence that our semantic theory must fit.

A semantic analysis of perception cannot help reflecting an underlying philosophical theory of perception, conscious or not. In section III we discuss several possible approaches to the semantics of NI perception, approaches suggested by various philosophical theories of perception. But we also present puzzles in the logic of perception which show that these approaches (including that via "possible worlds") are unsatisfactory.

On the basis of the evidence presented in sections II and III, it ap-

[6] See Austin's "Truth" in *Philosophical Papers* (New York: Oxford, 1979), pp. 117-133, and Russell's "The Philosophy of Logical Atomism" in R. C. Marsh, ed., *Logic and Knowledge* (New York: Capricorn, 1971), pp. 175-182.

pears that there is basically only one way to treat the semantics of NI perception sentences: to treat them as containing a hidden quantification over scenes and other situations in the world. In section IV I discuss as much of my theory of the scene-analysis semantics of NI perception sentences as I can without getting into set-theoretic technicalities.

This theory fits nicely with a realist philosophical-psychological account of perception to be found in the writings of Dretske, R. J. Hirst, and J. J. Gibson. In a sequel I will discuss this account, relate it to the semantics of NI perception sentences, and then go on to sketch my semantics for epistemic perception sentences.

The theory presented here has one especially interesting consequence for the philosophy of language. It shows in what way the reverence paid to the traditional notion of "logical" equivalence is misplaced and why attempts to prove Frege's claim that the reference of a sentence must be a truth value are completely circular.[7] This and some related conclusions are discussed in section V.

I. EPISTEMICALLY NEUTRAL PERCEPTION SENTENCES

If you, as special prosecutor, had to convince a jury that Nixon saw Rosemary Wood erase the crucial part of the Watergate tape, you would have a pretty good idea of the sort of evidence you would need. You would need to prove that Rosemary Wood did indeed erase the crucial part of that tape and that Nixon saw it. For example, a film of Nixon watching Miss Wood erase the tape would be pretty good evidence. But what if you had to prove that Nixon saw *that* Rosemary Wood erased the crucial part of the Watergate tape? Your old evidence would no longer suffice, since Nixon could claim that he didn't know it was the Watergate tape or that he didn't know she was erasing it or that he knew she was erasing part but didn't know it was the crucial part. To prove the stronger claim we would need evidence about Nixon's state of perceptual consciousness at the time of the seeing.

Because of the epistemical difficulties in knowing just what someone else is aware of in his perceptions, language provides us with epistemically neutral as well as epistemically positive perceptual reports. (1), (3), (5), and (7) are epistemically neutral; (2), (4), (6), and (8) are epistemically positive.

(3) Dick saw Rosemary remove the crucial part of the Watergate tape.

[7] This argument is used, e.g., by Donald Davidson in "Truth and Meaning," *Synthese*, XVII, 3 (September 1967):304–323. The history of and fallacy in this argument is discussed at length in the paper cited in fn 5.

(4) Dick saw that Rosemary removed the crucial part of the Watergate tape.
(5) Ralph saw a spy hiding a letter under a rock.
(6) Ralph saw that a spy was hiding a letter under a rock.
(7) The mother heard her baby crying.
(8) The mother heard that her baby was crying.

The difference between the two kinds of sentences is straightforward, but extremely important to an understanding of this paper. Let us belabor the point, to show that this is a difference we can and should hope to capture in a formal semantics.

There is a tendency for the hearer of (3), (5), or (7) to infer (4), (6), or (8), respectively. Doesn't that make the latter part of the meaning of the former? No. Such an inference is based not on the semantic content of (3), (5), or (7), but on a Gricean conversational implicature. That is, it is based not on the bare-bones meaning of the sentence, but on pragmatic considerations involving the listener's expectations as to when such a sentence is appropriate to a conversation. To see this, note that (3), (5), and (7) can be amplified so that the implicature can be "canceled." For example, (5) might be amplified by:

Ralph saw a spy hiding a letter under a rock, but thought she was tying her shoe.

No such amplification is consistent with the epistemically positive (6).

In chapter II of his book *Seeing and Knowing*,[8] Fred Dretske uses epistemically neutral perception sentences to argue that there is a particularly simple kind of seeing, what he calls "non-epistemic seeing" or "seeing$_n$." According to Dretske, what we see$_n$ "is a function solely of what there is to see and what, given our visual apparatus and the conditions in which we employ them, we are capable of visually differentiating" (76) and is independent of "the subtleties of epistemology." The central chapters of Dretske's book are devoted to spelling out conditions for (two kinds of) full-blooded epistemic seeing, seeing$_e$; these conditions involve seeing$_n$, belief, and counterfactuals involving the conditions of observation.

There certainly *are* two kinds of perceptual reports. Does this mean that there are two corresponding different ways of perceiving? This is an issue about which a great deal of philosophical ink has been spilled since the publication of Dretske's book. For my account I need only one kind of seeing. What I see is a scene *s* in the

[8] Chicago: University Press, 1969.

world. The difference between seeing$_n$ and seeing$_e$ is, loosely speaking, the difference between what is actually true in s and what facts about s I am actually aware of at the level of perceptual consciousness. (One *might* want to say that there are different ways of seeing$_e$ corresponding to different psychological states, but this is a different issue.)

Dretske's basic insight is very important. To understand the semantic content of epistemically positive perception sentences, one must first get straight about the much simpler epistemically neutral perception statements. This paper is devoted to unraveling the truth conditions of one kind of epistemically neutral perception sentence, namely, so-called "NI perception" sentences.

The most striking *syntactic* difference between the epistemically positive and neutral perception sentences is the occurrence or nonoccurrence of the word 'that' following the perception verb. There is, however, another syntactic difference. The *embedded sentence*[9] in the positive case has its verb conjugated normally; in the neutral case the verb can occur only in its naked infinitive (NI) form [(1) and (3) are examples] or in a gerundive (G) form [(5) and (7), for example]. The two types of perception sentences are called *NI perception sentences* and *G perception sentences*. We concentrate on the simpler NI perception sentences here, since the G perception sentences would get us involved in questions of tense and aspect which are best postponed.

As a footnote to section I, let us grant that there is one case where the distinction between epistemically neutral and positive perception sentences is hard to maintain, that being first-person present reports. It is difficult to maintain that (9) does not entail (10):

(9) I see the King of France combing his hair.
(10) I see that the King of France is combing his hair.

Difficult, but not impossible. The reason (10) seems to follow from (9) is that, if I am in a normal mental state, then I cannot truthfully assert that I see ϕ without being aware that ϕ is true. Thus again it is a pragmatic consideration that allows the inference from (9) to (10). If we put (9) in the past tense, this becomes obvious.

[9] The reader not familiar with transformational grammar may find it odd to call the phrases *Mary run* in *John saw Mary run* and *Mary to run* in *John expected Mary to run* "embedded sentences." With regard to the general issue, I refer the reader to any standard text on transformational grammar. In the case of NI perception sentences, the best reference is James Gee's "Comments on the Paper by Akmajian" in P. Culcover, T. Wasow, and A. Akmajian, eds., *Formal Syntax* (New York: Academic Press, 1977), pp. 461-483.

II. THE LOGIC OF NI PERCEPTION STATEMENTS

The basic assumption of this paper is that we do know, at some intuitive level, what it means for an NI perception statement to be true, and hence that it should be possible to make the truth conditions for such statements explicit. It is the kind of assumption that rests behind all work in the model-theoretic semantics of natural language. In this section we will examine some of the inferences that are judged valid and, hence, reflect on the truth conditions of NI perception sentences. This is the primary evidence with which we judge a semantic theory; do the inferences declared valid by the model theory square with the pretheoretic judgments of native speakers of the language?

Veridicality. In normal usage, NI perception statements are taken as veridical. Thus if I attempt to convince a jury that Dick saw Rosemary remove the crucial part of the tape by producing proof that Dick was under the influence of drugs and had a hallucination involving Rosemary, I will be laughed out of court. There may be *some* reading of (3) that would be true of Dick's drugged state, but it is not the important reading, the veridical reading. The truth of NI perception statements, under this common reading, is, as Dretske says, "a function . . . of what there is to see," and it is this reading we shall attempt to unravel. Having done so, we can then back up and see what modifications would be necessary to accommodate nonveridical readings.

Thus, in discussing the logic of NI perception sentences in this section, we will assume that the context makes it clear that it is the veridical reading that is intended. For example, we are interested only in that reading of (3) where, if it is true, then Rosemary did indeed do the deed. More generally, we have the following informal principle which must square with the model-theoretic account to be given:

Principle of Veridicality: For simple NI sentences ϕ,
(A) If a sees ϕ, then ϕ.

Extensionality of NI perception statements. There are two traditional tests to determine whether a verb creates an intensional or extensional context. One is whether we can substitute different descriptions of the same individual within such contexts without affecting the truth value of the sentences as a whole. The other is whether the contexts demonstrate quantifier-scope ambiguities. By these tests, at least, NI perception statements are extensional.

With respect to substitution, note the validity of the following argument:

Russell saw G. E. Moore get shaved in Cambridge.
G. E. Moore was (already) the author of *Principia Ethica*.
⊢ Russell saw the author of *Principia Ethica* get shaved in Cambridge.

Thus, our semantic theory should count as valid the following:

Principle of Substitution:
(B) If a sees $\phi(t_1)$ and $t_1 = t_2$ then a sees $\phi(t_2)$.

With respect to the scope ambiguities often associated with the terms *de dicto* and *de re,* observe that (1) is valid but (2) is not.

(1) Ralph saw someone hide a letter under the rock.
⊢ There was a particular person whom Ralph saw hide a letter under the rock.

(2) Ralph believed that someone had hid a letter under the rock.
⊢ There is a particular person whom Ralph believed to have hidden a letter under the rock.

Notice that we can also pull the quantifier out of object position in (1):

Same hypothesis as (1)
⊢ There is a particular letter that Ralph saw someone hide under the rock.

We can tentatively summarize the observations by (C), but we will discover some subtleties involved with (C) which will require us to modify the usual logical treatment of relative clauses.

(C) a sees some x such that $\phi(x)$
⊢ There is an x such that a sees $\phi(x)$

The same lack of scope ambiguity can be seen with other determiners. Consider the examples:

John wanted many women to leave.
John saw that many women left.
John saw many women leave.

In the first two there is an ambiguity as to the scope of 'many women', and a resulting ambiguity as to whether it is the speaker's or John's sense of the term 'many women' which is involved. In the NI perception sentence, however, there is no such ambiguity—the sense of 'many women' is the speaker's.

There is one kind of ambiguity that arises with perception verbs but not with the traditional verbs of propositional attitude, as in (3):

(3) Alice saw everyone on the road.

Here the ambiguity is between the reading where *see* is taking a noun phrase (NP) complement, as in (4a), or an NI sentence, as in (4b).

(4a) Alice saw everyone (who was) on the road.
(4b) Alice saw everyone (be) on the road.

Logical judgments involving 'and', 'or', *and* 'not'. We use 'not' here as it is used in natural language with verb phrases; thus ($\sim\phi$) denotes the verb-phrase negation of the sentence ϕ, as in the pairs:

(6) John left the room.
$\sim$(6) John didn't leave the room.
(7) Mary saw Bill run.
$\sim$(7) Mary didn't see Bill run
(8) Someone is on the road.
$\sim$(8) Everyone is not on the road, *or, less ambiguously,* No one is on the road.

If I saw John not leave the room then I certainly can't have seen him leave the room at the same time. That is, (D) is a valid principle:

(D) If a sees $\sim\phi$, then $\sim(a$ sees $\phi)$.

The converse is false, of course. Just because I didn't see John leave the room, it does not follow that I actually saw him *not* leave the room.

This brings up a point in connection with the principle of veridicality. Consider the following exchange from Lewis Carroll's *Through the Looking Glass:*[10]

"I see nobody on the road," said Alice.
"I only wish I had such eyes," the King remarked in a fretful tone.

A thoughtless application of the principle of veridicality might lead one to infer incorrectly from

(9) Alice saw nobody on the road.

that nobody was on the road. This sentence (9) is actually ambigu-

[10] Toronto: Bodley Head, 1974; ch. 7, p. 206.

ous between (10a) and (10b), with (10a) being the clearly preferred reading.

(10a) Alice didn't see someone (be) on the road; i.e., $\sim$[Alice saw (8)].
(10b) Alice saw everyone (be) not on the road; i.e., Alice saw $\sim$(8).

The King's move is an instance of the faulty converse of (D), another instance that shows it to be faulty.

Let us note in passing that principle (D) is not really new; it follows from two uses of the principle of veridicality, together with principles of logic that don't involve perception.

Now for some examples involving 'and' and 'or', connectives denoted by $\wedge$ and $\vee$, respectively.

McTaggart saw Russell or Whitehead get shaved in Cambridge.
Whitehead didn't get shaved in Cambridge.
$\vdash$ McTaggart saw Russell get shaved in Cambridge.

Notice that the inference does not go through for 'believes that' but, under one reading, does go through for 'saw that'. The inference can be derived from (A) together with (E) and principles of logic not involving perception.

(E) If a sees $(\phi \vee \psi)$ then a sees ϕ or a sees ψ.

If $(\phi \vee \psi)$ is true of what a sees, then either ϕ or ψ is true of it. Even more straightforward is:

(F) If a sees $(\phi \wedge \psi)$ then a sees ϕ and a sees ψ.

Anaphora. In discussing the syntax of NI perception sentences, James Gee makes crucial use of the observation that these sentences allow anaphora with respect to the NI complements, as in *John saw Mary run and Bill saw it too,* with the anaphoric 'it' (*op. cit.*). The observation is equally important from a semantic point of view, since it signals reference to something. As Quine, with his ontologically sparse universe, writes:

> . . . to be assumed as an entity is, purely and simply, to be reckoned as the value of a variable. In terms of the categories of traditional grammar, this amounts roughly to saying that to be is to be in the range of reference of a pronoun. Pronouns are the basic media of reference; . . . we are convicted of a particular ontological presupposition if, and only if, the alleged presupposition has to be reckoned among the entities over which our variables range in order to render one of our affirmations true.[11]

[11] *From a Logical Point of View* (Cambridge, Mass.: Harvard, 1961), p. 13.

We believe that this dictum is too restrictive, that there are other ontological commitments hidden in natural language, but we don't need to defend that position here, for the facts fit Quine's conditions. Consider the following examples. Anaphora occurs in (11)-(13), but is ungrammatical in (14) and (15). (We follow the linguists' convention of marking ungrammatical expressions with an *.)

(11) Whitehead saw Russell wink. McTaggart saw it too.
(12) Bob heard someone sing "Diamonds and Rust". John didn't hear it.
(13) Whitehead expected Russell to wink. McTaggart expected it too.
(14) Bob persuaded John to sing. *John persuaded it too.
(15) *John made Mary run and Bill made it too.

To see the semantic import of anaphora in NI perception sentences, notice the difference between (a) and (b) in (16):

(16a) Ralph saw Orcutt kiss someone. David saw it, too.
(16b) Ralph saw Orcutt kiss someone. David saw Orcutt kiss someone, too.

The difference is that (a), unlike (b), implies that Ralph and David saw Orcutt kiss the same person. Thus, the 'it' in (16a) cannot be just a substitute for the phrase 'Orcutt kiss someone'. Rather, it is being used to refer to something.

But what does 'it' refer to? The answer seems pretty clear, intuitively. It is some event, or scene, witnessed by both Ralph and David, in which Orcutt kissed a particular person. (This is an oversimplification, since Ralph and David will probably not see exactly the same scene. Rather, the scenes seen by each will be of the type where Orcutt kisses a particular person.) The goal of section III will be to convince the reader that only by taking seriously this reference to scenes can one develop a satisfactory semantic account of NI perception sentences which squares with principles (A)-(F) above.

The logic of nonlogical expressions? To anyone (like the author) steeped in the model-theoretic tradition of Tarski, there is an obstacle to our endeavor—namely, its apparent incoherence. Model theory (and possible-world semantics in particular) distinguishes between logical symbols, those signs (like 'and') whose meaning is fixed regardless of how the world is, and nonlogical symbols (like 'kick') which are taken to be completely uninterpreted signs whose interpretation must be provided, that interpretation varying from model to model. The verb 'see' is certainly not a logical symbol,

since who sees what is very much a function of the way the world is. On the other hand, if 'see' is considered to be simply an uninterpreted sign, it doesn't have any logic. But perception *does* have a logic to be explained. We have seen arguments that are valid regardless of how the world happens to be, given the meaning of the sentences, valid principles that need to be accounted for in the semantics. This is the tip of an ancient iceberg which has sunk many a semantic ship. We must distinguish between (uninterpreted) sign and (interpreted) symbol much more carefully in the study of natural language than in the study of mathematical theories. Only the symbol *see,* the word 'see' interpreted as the relation of seeing, has a logic in any sense. The sign has no logic. The problem for us is to figure out what sort of a relation *see* is a symbol for—"sort" in the sense that we must determine what sort of things are seen. This is the problem taken up in the next two sections.

III. FOUR PUZZLES IN THE LOGIC OF PERCEPTION

The puzzle of the missing property. John Austin, in discussing the grammatical form of perception sentences, claims to have seen a man born in Jerusalem get shaved in Oxford.[12] G. E. M. Anscombe finds this extremely puzzling and uses it to argue that we see intentional objects, not just physical objects.[13] Why?

The puzzle of logical equivalence. Can a man's death be attributed to a breakdown in the laws of modal logic? Brown is accused of murdering his mortal enemy Fred Smith. At Brown's trial, Smith's wife, Mary, testifies as follows: "Brown and I happened to enter the room at the same time, by different doors. Fred, facing my door, saw me enter. I saw Brown enter, but Fred did not see Brown enter." Brown, who is pleading self-defense, needs to refute the claim that Fred did not see him enter the room. So he calls in an expert witness, a famous modal logician *K* who "proves" that, by the very laws of logic, the situation could not possibly be as Mary Smith described! How?

The puzzle of Russell's schoolchildren. In 1927 Russell and his wife, Dora, opened a private school called Beacon Hill, aimed at educating small children while challenging all the sacred cows of English education. Given Russell's views about numbers and other matters, we can imagine how he might have gone about teaching his children about counting via one-to-one correspondences. Imagine a room full of children, with both Russell and Dora seeing all

[12] *Sense and Sensibilia* (New York: Oxford, 1962).
[13] G. E. M. Anscombe, "The Intentionality of Sensation: A Grammatical Feature," in R. J. Butler, ed., *Analytic Philosophy* (New York: Oxford, 1962).

the children. Russell instructs each boy to touch a girl, and indeed, Russell sees each boy touch a girl. Russell doesn't see any girl get touched by more than one boy. From these facts we (and Russell, if he is perceptually aware) can conclude that there are at least as many girls as boys, since what Russell sees provides us with a one-to-one function from the boys onto a subset of the girls.

Now this is really very odd, because Dora sees everything Russell sees but, from her vantage point, sees more. Namely, she sees that some girls are being touched by several boys, boys using both hands to touch girls. She sees more, but from this report of what she sees we are not able to conclude as much as we could from the report of what Russell saw. Namely, we cannot conclude from the report of what *she* saw that there are at least as many girls as boys. What is going on here, and what does it tell us about the semantics of perception?

If the perceptual situations described above do not seem very puzzling, so much the better, for we want to show that they provide real obstacles to certain seemingly plausible approaches to the semantics of NI perception sentences. First, however, an old chestnut.

The puzzle of the dirty children. Imagine n children playing together. The mother of these children has told them that if they get dirty there will be severe consequences. So, of course, each child wants to keep clean, but each would love to see the others get dirty. Now it happens during their play that some of the children, say k of them, get mud on their foreheads. Each can see the mud on others but not on his own forehead. So, of course, no one says a thing. Along comes the father, who says, "At least one of you has mud on your head," thus expressing a fact known to each of them before he spoke (if $k > 1$). The father then asks the following question, over and over: "Can any of you prove you have mud on your head?" Assuming that all the children are perceptive, intelligent, truthful, and that they answer simultaneously, what will happen?

There is a "proof" that the first $k - 1$ times he asks the question, they will all say "no" but then the kth time the dirty children will answer "yes."

The "proof" is by induction on k. For $k = 1$ the result is obvious: the dirty child sees that no one else is muddy, so he must be the muddy one. Let us do $k = 2$. So there are just two dirty children, a and b. Each answers "no" the first time, because of the mud on the other. But, when b says "no," a realizes that he must be muddy, for otherwise b would have known the mud was on his head

and answered "yes" the first time. Thus a answers "yes" the second time. But b goes through the same reasoning. Now suppose $k = 3$; so there are three dirty children, a, b, c. Child a argues as follows. Assume I don't have mud on my head. Then, by the $k = 2$ case, both b and c will answer "yes" the second time. When they don't, he realizes that the assumption was false, that he *is* muddy, and so will answer "yes" on the third question. Similarly for b and c.

There are several puzzles here. The main one is the role of the father's first announcement. What is it? For $k > 1$ it seems to convey no new information to the children, but it is crucial to the argument. Without it they would go on saying "no" till doomsday (mother's return).

Notice the number of ways perception enters this puzzle. Each child sees mud on the muddy heads. No child sees mud on himself. Each child hears his father's announcement and his questions, as well as the other children's answers. An adequate semantics of epistemic perception should allow us to see just what role the father's announcement plays, as well as to discover the unrealistic assumptions in the above "proof".

First-order predicate calculus. Before getting to possible treatments of the semantics of NI perception sentences, let us fix ideas and terminology by reviewing the prototypical semantics for a formal language—the standard first-order predicate calculus as it is presented in most modern logic textbooks.

This version of the predicate calculus has both a *syntactic* and a *semantic* component. On the syntactic side there are *sentences* built up from other sentences by connectives $\wedge$ ("and"), $\vee$ ("or"), $\sim$ ("not"), and by means of quantifiers $\exists$ ("something"), and $\forall$ ("everything"). At the start, or atomic level, there are certain basic uninterpreted sentences like $(x\ R\ y)$ $W(z)$, $G(x, y, z,)$, $x = y$. Thus, for example,

(1) $$\forall x[\sim W(x) \vee \exists y(x\ R\ y)]$$

might be read as

> For everything x, either x is not a W or else there is some y such that x bears relation R to y.

The semantic side of the first-order predicate calculus insists on an interpretation for the basic sentences like $(x\ R\ y)$ and an interpretation for the 'thing' in 'everything' and 'something'. That is, it insists that a *universe* or domain M be specified consisting of the things it is you are talking about, and it insists on the symbols R,

W being interpreted. The symbol R must be interpreted as some relation between pairs of objects in M. W must be interpreted as some property of objects in M.

Example. Let M be the set of people and books in the nearest library. Interpret W as the property of being a woman and $(x\ R\ y)$ as the relation of x reading y. Then (1) expresses everything in the library which is a woman is reading something in the library, and (1) will be *true* in this interpretation just in case every woman in the library M is reading something in the library.

We will not bother to spell out, in any formal way, just how one goes about explicating terms like 'relation', 'property', 'sentence', 'interpretation', 'true', just now. At some point we will have to do this for a different version of the first-order predicate calculus; for now this informal account will suffice.

We now turn to a discussion of three philosophical theories of perception which suggest seemingly plausible semantic accounts of NI perception statements. The puzzles cited above will be used to discredit these accounts.

The naive realist's logic of perception. The naive realist position is basically that perceiving a physical object is a direct confrontation between the perceiver a and the perceived object b; say: a sees b. On this view perception provides us with direct knowledge of b and its properties without any mediating factors. No homunculus. No conscious or unconscious interpretation of a mental image. No sense data.

It is the view that is uncritically reflected in most treatments of the logic of perception—most such accounts amounting to no more than a few misleading exercises in logic textbooks where a sentence like *Dick sees Jane* or *Jane sees a woman* are translated as:

$$d\ S\ j$$
$$\exists x\,[(j\ S\ x) \wedge W(x)]$$

where our domain M of things is a set M of macroscopic physical objects, say, the library in the example cited above, $x\ S\ y$ is interpreted as x sees y, $W(x)$ as x is a woman (as above), and d, j are interpreted as Dick and Jane, respectively.

The difficulty with this proposal is brought out by the puzzle of the missing property. Consider the following sentences:

(2) Austin saw a man born in Jerusalem.
(3) Austin saw a man shaved in Oxford.
(4) Austin saw a man born in Jerusalem get shaved in Oxford.

The difference between the preferred readings of (2) and (3) is brought out in (4), which implies both (2) and (3). Sentence 2 might be symbolized by the naive realist as

$$(\exists x)[a\ S\ x \wedge B(x)]$$

if we interpret a as Austin and $B(x)$ as the property of being born in Jerusalem. However, the naive-realist logician simply cannot express (3) or (4). The point is made more clearly with a simpler example, say,

(5) Whitehead saw Russell wink.

The closest the naive-realist logician can come to expressing this would be, say,

(6) $$(w\ S\ r) \wedge T(r)$$

where $T(x)$ is interpreted as x having the property of winking. However, (6) is really the formal expression of (7):

(7) Whitehead saw Russell and Russell winked (at the same time).

(7) is a consequence of (5), but not vice versa, since we can well imagine a situation where Russell winked at someone, in Whitehead's presence, in such a way that Whitehead didn't see him wink. In such a situation (7) and hence (6) would be true, but (5) would be false.

Just because the most obvious thing doesn't work, it is not necessarily the case that it's impossible for the naive-realist logician to express (5), but it is not difficult to prove that he is out of luck, that any consequence of (5) that he can express is a consequence of the weaker (7).

It follows that the semantics of perception that reflects naive realism is not adequate. We usually see an object without seeing all its properties, even visible properties. In particular, to return to sentence (3), the naive-realist semantics is inadequate because it gives us no way to assert that Austin saw a certain event, an event where some man was shaved. Whatever events are, whatever it was that Austin saw, it was not a bare physical object as dictated by the naive-realist logician. (I have used 'naive' here because I consider the semantics I give in section IV to be compatible with a form of realism.)

Propositional theories of perception and the problem of logical equivalence. The most important philosophical problem about perception is the relationship between perception and knowledge.

How is it that the private experiences that constitute our perceptions cause us to know facts about the external world? Discussions of this epistemological problem almost inevitably find it mixed up with a metaphysical question: What is the nature of the objects of perception? If naive realism is wrong, if perception is not a simple direct confrontation with physical objects, then what are the objects of perception? Suggestions that have been put forward include images, sense data, mental representations, and propositions.

The propositional theories of perception argue that the epistemological and metaphysical questions are really the same. This type of theory argues that we never simply see a tomato, say, but rather we see that something is a tomato, or that something is red and roundish. We see that things have certain properties and stand in certain relations to one another. In other words, what we see are facts, not simple physical objects. According to this approach, seeing *is* a way of knowing or believing, and the objects of perception are the same sorts of objects as the objects of knowledge and belief—that is, propositions.

This theory suggests treating the semantics of perception in the way that has proved most successful for the semantics of knowledge and belief—the modal logician's possible-world semantics—and is the direction taken up by Hintikka and pursued by Thomason and Niiniluoto. According to Hintikka: "To specify what *a* perceives is to specify the set of all possible worlds compatible with his perception . . . [where] the notion 'compatible with what *a* perceives' is taken as unanalyzable" (1975, p. 61).

Hintikka uses Anscombe's discussion of intentionality in perception to motivate his modal treatment. Although he never states what the intended scope of his analysis is, whether it is to include NI perception sentences or not, he does argue that within his semantics he is able to make "the distinction [which] at any rate captures some of the things Miss Anscombe apparently wants to say of the difference between intentional and material objects of perception, and of the attitudes philosophers have taken to them" (1975, sec. III). Given that Anscombe's observations on intentionality and grammaticality are directed toward NI reports, one is certainly left with the impression that such sentences are intended to be within the scope of Hintikka's theory.

Niiniluoto, in his paper developing Hintikka's theory in some formal detail, is more explicit about the intended scope: "On the other hand, in our analysis, all seeing involves propositional seeing, but often in quite a complex way. Dretske's notions of non-epistemic and epistemic seeing seem to mark the extreme points between which most types of perceptual situations are situated" (277).

We want to show that the puzzle of logical equivalence (381) shows that the propositional possible-worlds account cannot get the right logical laws to fall out for NI perception sentences and, hence, that there is no reason to suppose that it gives the best possible treatment of epistemically positive perception sentences either. To show the problem, all we need to know about "possible worlds" is that logically equivalent sentences are true in the same possible worlds.

Return to Mary Smith's testimony (381), and let us show how K attempts to convince the jury that Mary has violated the laws of the logic of perception. Let us use m, f, and b for Mary Smith, Fred Smith, and Brown, respectively. Let us also use $F(x)$ for the property of entering by the door more or less in front of Fred, $B(x)$ for entering by the other door. According to Mary's testimony:

(8) m saw $B(b)$

(9) f saw $F(m)$

(10) $\sim(f$ saw $B(b))$

K shows that Mary is inconsistent by using the accepted principles (A)-(F) of the logic of perception, together with the assumption that, if ϕ and ψ are logically equivalent, then:

If f sees ϕ then f sees ψ.

K argues as follows: By (8) and (A), we have $B(b)$. Another application of (A) gives $\sim(f$ saw $\sim B(b))$; that is, Fred didn't see Brown not enter by the door by which he in fact entered. But $F(m)$ is logically equivalent to $(F(m) \wedge B(b)) \vee (F(m) \wedge \sim B(b))$; so we have

(11) f saw $[(F(m) \wedge B(b)) \vee (F(m) \wedge \sim B(b))]$

But then, by (E), we have either

f saw $(F(m) \wedge B(b))$ or f saw $(F(m) \wedge \sim B(b))$

The latter implies f saw $\sim B(b)$, which we showed above to be false. But the former implies f saw $B(b)$, contradicting (10). The defense rests.[14]

[14] Some logicians may be more inclined to give up (E) than logical equivalence. If any of the jurors balk for similar reasons, K can give a proof that uses only principle (B) by modifying the proof mentioned in fn 7. Let t_1 and t_2 be the following definite descriptions: *the x such that* $(F(x) \wedge x = m)$ and *the x* $(B(b) \wedge x = m)$. Since $F(m)$ and $B(b)$ are both true, t_1 and t_2 both denote Mary, so $t_1 = t_2$ is true. But $F(m)$ is logically equivalent to $t_1 = m$, $B(b)$ is logically equivalent to $t_2 = m$. Thus K can argue as follows. Since f *saw* $F(m)$ is true, so is f *saw* $(t_1 = m)$, by logical equivalence; hence, by (B), we have f *saw* $(t_2 = m)$. Another appeal to logical equivalence gives f *saw* $B(b)$. Q.E.D.

We take it as obvious that this argument is wrong, that the situation could have been as Mary described it to be, so that (8), (9), and (10) are jointly consistent. By paraphrasing (11) in English [see (12)] we see that the substitution of logical equivalents was the false step. Just because Fred saw Mary enter, it does not follow that

(12) Fred saw either both Mary and Brown enter or Mary enter but Brown not enter, by their respective doors.

The problem is, of course, the old problem of logical omniscience. For the modal logician is committed to the painful claim that, if you know or believe or doubt ϕ, you must also, in some sense, know, believe, or doubt any ψ logically equivalent to ϕ. With knowledge, belief, and doubt there may be *some* sense in which you doubt ψ if you doubt the logically equivalent ϕ, etc., but with perception the pain becomes acute. It is just wrong to think that if you see ϕ you also see ψ.

It might be thought that this illness of possible worlds would infect any model-theoretic attempt to treat the semantics of NI perception sentences. After all, logical equivalence *is* logical equivalence, isn't it? But is it?

The puzzle of Russell's schoolchildren provides even more serious problems for the possible-worlds theory of perception, because it provides for a clear-cut logical inference that cannot be derived. However, the proof of this would take us further into other possible worlds than I, being partial to this one, care to go.

Naive adverbial theories of perception and ad hoc semantics. Adverbial theories of perception, seeing problems with more traditional approaches, claim it is simply a mistake to talk about objects of perception at all. This line of thinking compares a sentence like *John sees Mary run* with *John dances a jig*. It is mistaken to take the latter as asserting $\exists x$ [jig(x) $\wedge$ j dances x], since there is no external object x that is a jig danced by John. Rather, the phrase 'a jig' is functioning adverbially, to modify dance, to tell us how John danced. Similarly, the argument goes, the phrase 'Mary ran' is functioning to tell us how John is seeing.

If we are willing to fall back to the adverbial theory of perception, we can develop a semantics that is not far removed from that of the naive realist. Instead of having a single sentence $x\ S\ y$, to be interpreted as x sees y, we have a whole family of sentences $S_\phi(x)$, interpreted as x sees ϕ. This gets around the problem of logical equivalence, since, even if ϕ and ψ are logically equivalent, S_ϕ and S_ψ are different predicate symbols. This approach has the advan-

tage over the last approach of not declaring valid any obviously invalid inferences.

The problem with this approach is obvious. It simply gives up the main task of discovering the truth conditions for a sentence of the form *a* sees ϕ. As a result, none of logical principles (A)–(F) of section II, principles that we want to drop out as theorems of our semantics, are justified by this approach. They couldn't be, since we could pull the same adverbial trick with 'believes', 'expects', 'persuades', 'doubts', etc., verbs for which the principles fail to hold.

We could add some ad hoc "meaning postulates" as special axioms about the new predicate symbols S_{ϕ_1}, S_{ϕ_2}, . . . , axioms like

$$S_{\phi(b)}(a) \wedge b = c \rightarrow S_{\phi(c)}(a)$$

$$S_{\phi \wedge \psi}(a) \rightarrow S_{\phi}(a) \wedge S_{\psi}(a)$$

which would limit the kinds of interpretations the symbols S_ϕ could take. Of course, there would have to be an infinite number, since different complement sentences ϕ give rise to distinct predicate symbols S_ϕ. Worse, however, is that the proposal suffers from the old "quantifying in" problem. For example, to express (C), what sentence would you put in place of the question mark below?

$$S_{\exists x \phi}(a) \rightarrow \exists\, x\, S_{?}(a)$$

The adverbial theory does contain a kernel of truth—an insight that one can exploit in proving a completeness theorem for the logic of perception.

IV. ON SEEING SCENES

The objects of perception are doubly connected to us—through the laws of nature and through those of language. On the one hand, they causally effect us. On the other, they must somehow be able to support the truth of sentences (ϕ, for example) to account for the truth of NI perception sentences like *a* sees ϕ. The split between the naive-realist and the propositional theories of perception is a reflection of this dual role of the objects of perception.

When I look around I cannot see a single thing-in-itself, some sort of ideal physical object stripped of its properties and its relations with other objects. What I do see is a scene, a complex of objects having properties and bearing relations to one another. The properties and relations are every bit as important to what I see as the idealized thing-in-itself. In fact, what really counts is the whole complex of objects-having-properties-and-bearing-relations which constitutes the scene.

The scene I see is part of the way the world happens to be here and now. As such, it is certainly the kind of thing that causally affects me. The objects reflect light. How light gets reflected depends on the physical properties of the objects and their physical relation to one another. On the other hand, by being a part of the way the world is, the scene inherits the world's connection with language and, hence, is able to support the truth of sentences.

Scenes as supports for the truth of sentences. Any part of the way the world M happens to be I call a *situation* in M. *Scenes* are visually perceived situations. The central notion in the theory is that of a scene or other situation s *supporting the truth* of a sentence ϕ in M.

If ϕ is a true sentence (true in M), there will in general be many different scenes or situations that support the truth of ϕ. For example, if I look at my desk from different positions in my office, I will see many slightly different scenes; most of which will support the truth of

(1) A pile of unanswered mail is on the desk.

Some scenes will fail to support the truth of (1), e.g., the scene seen from under the desk. Unfortunately, no such scene can make (1) false. I can change the truth value of (1) by answering my mail or by throwing it away, but not by simply crawling under the desk!

Whether or not a scene or situation s supports the truth of a sentence ϕ in M depends, in general, on s, ϕ and on M—the way the world is. For example, the scene Austin saw supported the truth of

A man born in Jerusalem is being shaved in Oxford.

but the man's having-been-born-in-Jerusalem is not part of the scene; it is just part of the way the world happened to be at the time. When it comes to the formal treatment, this fact causes us to adopt a syntax for sentences which is more like the noun phrase/verb phrase (NP/VP) of natural language than that of first-order predicate calculus.

For any sentence ϕ, we let $[[\phi]]^M$ denote the set of all situations in M that support the truth of ϕ. If ϕ is true, then $M \in [[\phi]]^M$, and conversely, if $M \notin [[\phi]]^M$, then ϕ is false. With this notion in hand, we can turn to our basic proposal.

The basic proposal. Light from the scene before my eyes is focused by the lenses of my eyes onto my retinas, thereby initiating an in-

credibly complex chain of electrochemical activity. When we turn to the epistemically positive perceptual reports, we will have to relate this activity with perceptual reports in a meaningful way. But since the semantic function of NI perceptual reports is to report on what is perceived by the perceiver, not on what happens in his head, we can temporarily ignore the causal process. Thus, we propose to interpret a NI perception statement "a sees ϕ" as asserting that

(2) a sees a scene s that supports the truth of ϕ

i.e., for some situation s in M,

(3) $(a \text{ sees } s) \wedge (s \in [\![\phi]\!]^M)$

The two conjuncts of (3) reflect the two roles of the objects of perception discussed above—that of causally affecting a and that of supporting the truth of ϕ. To make the proposal precise, we will need to: (i) explain exactly how we represent the way the world is, (ii) explain exactly how we represent situations, and (iii) define $[\![\phi]\!]^M$ precisely. This we will do in *Situation Semantics*.[15] I think that our pre-theoretic understanding of scenes and other situations is sufficient to understand the basic proposal and to see how it solves the puzzles presented in section III.

Solutions to the first three puzzles. First, for the puzzle of the missing property. If Austin saw a man from Jerusalem get shaved, what did he see? He saw a certain scene s, one part of which consisted of a man, say b, and the property of being shaved. The man, b, also had the property of having been born in Jerusalem, but that property was not part of what Austin saw, so it was not part of the scene.

As for the second puzzle, the puzzle of logical equivalence, there are two scenes involved, both part of the actual world M of the story: the scene s_m seen by Mary Smith and the scene s_f seen by Fred Smith. If Mary is telling the truth, then the scene s_f seen by Fred contains Mary entering the room by the door in front of him but does not contain Brown entering by the other door, the latter being a part of s_m. Thus, using the notation from section III, we see that s_f supports the truth of $F(m)$ but fails to support $B(b)$, whereas s_m

[15] The book being written with Perry mentioned in fn 5. I should say here that my ideas about spelling out (i)-(iii) have changed quite a bit during my work with Perry, another reason for not attempting to spell them out here.

does support $B(b)$. The truth of (8), (9), and (10) can be rephrased as:

(8′) $s_m \, \varepsilon \, [\![B(b)]\!]^M$

(9′) $s_f \, \varepsilon \, [\![F(m)]\!]^M$

(10′) $s_f \, \varepsilon \, [\![B(b)]\!]^M$

It is now perfectly clear what is wrong with K's argument. The scene s_f seen by Fred does not contain Brown at all and so couldn't possibly be a scene where $(F(m) \wedge B(b)) \vee (F(m) \wedge \sim B(b))$.

How to make a scene. The first two puzzles suggest a rather simple modification of the naive realist's logic of perception. Namely, we could try letting the objects of perception consist of pairs $\langle b, p\rangle$ where b is a physical object and p is a property or set of properties that it possesses. The puzzle of Russell's schoolchildren shows that no such simple modification can work and shows much more clearly just how scenes function and what their nature is.

We perceive not just objects and their individual properties, but also relationships between things: the paper *on* the desk, the sled *in* the snow, this boy *kissing* that girl. These relations between objects are also part of the scenes we see.

Recall that in the puzzle of Russell's schoolchildren we were able to make the following valid inference:

(4) Russell saw each boy touch (at least) one girl.
(5) Russell didn't see any girl get touched by more than one boy.
⊢ (6) There are at least as many girls as boys.

A routine application of the Löwenheim-Skolem theorem shows that there is no way for the naive-realist logician (modified or not) to obtain this inference. In fact, he can't even state it, since the conclusion asserts the existence of a one-to-one function from the boys into the girls.

The relation $\mathcal{T}$ of two objects touching one another is one of the ways we organize the world. At any given time the relation has a certain extension, the pairs of objects $\langle x, y\rangle$ which are touching. In the world M of the schoolchildren, this relation has a certain extension, say T. What can we say about T from (4) and (5)? Strangely, (5) alone tells us absolutely nothing about T, and (4) tells us something about T only indirectly. Let s be the scene Russell saw, and let T_s be the set of pairs $\langle x, y\rangle$ such that Russell saw x touch y. Then T_s is a subset of T. (4) tells us a positive fact about T_s, (5) a

negative fact:

(4′) For every boy b there is a girl g such that $\langle b, g\rangle \, \varepsilon \, T_s$.
(5′) ~(There is a girl g and two distinct boys b_1, b_2 such that $\langle b_1, g\rangle \, \varepsilon \, T_s$ and $\langle b_2, g\rangle \, \varepsilon \, T_s$).

From (4′), it follows that T_s contains a function (thought of as a set of ordered pairs) from the boys into the girls. From (5′) it follows that any such function is one to one.

From these facts about T_s we learn indirectly that T contains a one-to-one function from the boys to the girls, and it becomes clear why seeing more can sometimes be seeing less. We could not discern the existence of such a one-to-one function from what we knew of the scene Dora saw.

We can summarize our observations as follows. We see scenes in the world, parts of the way the world is. If our semantics represents the world as some kind of model M, then the scenes and other situations will be something like partial submodels of M. Our theory will not give an outright recursive definition of "truth (or satisfaction) in M." Rather, it will give a recursive definition of $[\![\phi]\!]^M$, with truth as derivative. Some of the clauses in this definition are obvious:

$$[\![\phi \wedge \psi]\!]^M = [\![\phi]\!]^M \cap [\![\psi]\!]^M$$
$$[\![\phi \vee \psi]\!]^M = [\![\phi]\!]^M \cup [\![\psi]\!]^M$$

To get other clauses right requires us to rethink the syntax we have inherited from first-order logic and come up with a syntax more like the noun phase/verb phase structure of natural language. Indeed, it is very tempting to think that the structure of the simplest sorts of sentences of natural language arises out of our perceiving objects-having-properties and objects-bearing-relations-to-one-another.

The uniqueness principle (*). It is not part of the task of model-theoretic semantics to tell us which scenes we see, any more than it tells us who loves what or who kicks what. This is a task for philosophers and scientists. There is one thing we can say, however.

All the principles (A)–(F), and some others, fall out of the semantic theory we have sketched. There are some other plausible candidates that don't, though. For example:

(G) If a sees ϕ and a sees ψ, then a sees $(\phi \wedge \psi)$.

The hypothesis gives us scenes s_1 and s_2 seen by a, possibly distinct,

where ϕ and ψ are true, respectively. It does not give us a scene s seen by a where both are true.

In normal human vision, we see at most one scene at a time. For example, in reporting what we see, we do not say "I see ϕ with my left eye and ψ with my right." The way we talk has built into it an assumption of uniqueness of seen scenes:

(*) If a sees s_1 and a sees s_2, then $s_1 = s_2$.

We can either think of (*) as part of the theory of normal human vision or transport it into the semantic theory of restricting attention to interpretations where (*) is true. I am tempted to the latter strategy, but it does rule out certain logical possibilities—possibilities which may in fact be realized by "split brain" patients.[16]

The possibilities could also be realized by conceivable artificial vision systems set up to view multiple scenes, but integrating certain relevant type of information derived from such scenes. For such a system (*) and (G) would fail. However, if we do assume (*), then (G) and all the other instances of intuitively valid principles that I have thought of do follow.

I find extremely interesting this split into those principles, like (A)-(F), which follow automatically from the basic proposal made in section IV, and those, like (G), which need the uniqueness assumption (*). It exemplifies a principle of Russell:

> Logic shows the possibility of hitherto unsuspected alternatives more often than the impossibility of alternatives which seemed *prima facie* possible. . . . it liberates imagination as to what the world *may* be, it refuses to legislate what the world *is*.[17]

Conclusion. I hope to have shown how some mildly puzzling features of perception and NI perceptual reports have a relatively straightforward explanation. I have consciously avoided formal details, but firmly believe that the proof of the pudding lies in working out those details.

By concentrating on NI perception sentences I have avoided most of the interesting problems usually associated with propositional attitudes. But I have done so with an eye on the semantics of epistemically positive perceptual reports, to be taken up in a sequel. That theory depends heavily on the theory sketched here.

[16] It may be that the best way to speak of such subjects is in terms of left and right hemisphere scenes, i.e., scenes that initiate activity to these respective hemispheres. In special circumstances, these can be quite distinct, with verbal reports describing one, written reports the other.

[17] *Our Knowledge of the External World* (La Salle, Ill.: Open Court, 1914), p. 8.

V. APPLICATIONS

There are some morals for the philosophy of language to be drawn from the analysis of the semantic of NI perception sentences presented here. We discuss three of them here quite briefly.

Logical equivalence and strong equivalence. We have seen that sentences that are usually called logically equivalent need not be supported by the same situations. Recall that ϕ is true in M if and only if $M \,\varepsilon\, [\![\phi]\!]^M$. Thus ϕ and ψ are logically equivalent (in the usual sense) just in case, for all M, $M \,\varepsilon\, [\![\phi]\!]^M$ if and only if $M \,\varepsilon\, [\![\psi]\!]^M$. Since the term 'logical equivalence' has been usurped, let us coin a new phrase and call ϕ and ψ *strongly equivalent* (written $\phi \Leftrightarrow \psi$) if, for all M, $[\![\phi]\!]^M = [\![\psi]\!]^M$; i.e., if ϕ and ψ are supported by exactly the same situations.

Similarly, we will say that ϕ *strongly implies* ψ ($\phi \Rightarrow \psi$) if every situation that supports ϕ also supports ψ. This form of implication seems much closer to what we use (and are justified in using) in everyday situations than so-called "logical implication." The reader is invited to check his intuitions with the following:

$$(\phi \wedge \psi) \Leftrightarrow (\psi \wedge \phi)$$

$$(\phi \vee \psi) \Leftrightarrow (\psi \vee \phi)$$

$$(\phi \wedge \psi) \Rightarrow \phi$$

$$\phi \Rightarrow (\phi \vee \psi)$$

In general, we do not have $\phi \Rightarrow (\psi \vee \sim\psi)$ or similar irrelevancies.

Syntactic inadequacies in the predicate calculus. We can use the definition of strong equivalence to clarify a remark made in section IV (393). The traditional syntax of the first-order predicate calculus is formulated in a way that sometimes conflates sentences that are not strongly equivalent but are "logically" equivalent. Consider, for example:

(1) Someone wearing a bolo tie kissed Mary.
(2) Someone was wearing a bolo tie and kissed Mary.

I may have seen someone wearing a bolo tie kiss Mary without seeing him wearing the tie. (1) may be true in the scene I see, without (2) being true. (1) and (2), on the tradition approach, are logically equivalent, both of the "logical form" (3):

(3) $$(\exists x)\,[W(x) \wedge (x\ K\ m)]$$

but (1) does not strongly imply (2). This is why, in developing a

formal language to mirror simple NI perception sentences, we will need a syntax that reflects the NP/VP (noun phrase/verb phrase) structure of natural language.

On quantifying over "abstract objects." If we represent the way the world is as some sort of set-theoretic structure M, then types of situations in M will be some sort of partial substructures. We do not want to go into details of this representation here, but notice that if our proposal in section IV is correct, then in a sense NI perception sentences express a hidden quantifier over these situations in M and, hence, might be said to quantify over abstract objects.

Let LS be the abstract language of situations, where we allow explicit quantification over arbitrary situations in M. This language can express facts about M like (4)–(7):

(4) $$\phi \wedge \forall x \forall s [x \; P \; s \rightarrow s \notin [\![\phi]\!]]$$

(5) $$\exists s [a \; P \; s \wedge s \in [\![\phi]\!]]$$

(6) $$\forall s_1 \forall s_2 \forall x [(x \; P \; s_1 \wedge x \; P \; s_2) \rightarrow s_1 = s_2]$$

(7) $$\exists s \forall x \sim (x \; P \; s)$$

A sentence like *The tree fell but no one saw it fall* might be expressed in form (4). (5) is our form of translation of *a* sees ϕ. (6) is principle (*) from section IV. (7), which expresses *There is a situation no one sees,* is a consequence of (6), since, on cardinality grounds (Cantor's theorem), there are more situations than there are physical objects.

The language LS is the formal version of the language we use in speaking about scenes and other situations in the world, in this general abstract way. It can mimic ordinary quantification over arbitrary sets of objects and so is what logicians call a "higher-order" logic. It is so expressive that there is (provably) no hope of giving a complete effective set of inference rules for LS.

However, there is a sublanguage LP of LS which is simple enough to allow a completeness theorem but which still allows us to express (4)–(6) above, namely, a sublanguage that allows only "bounded" quantifiers over scenes and other situations, as

$$\forall s [a \; P \; s \rightarrow \ldots]$$

$$\exists s [a \; P \; s \wedge \ldots]$$

where P is a predicate symbol that directly relates a and s. LP allows us to speak of perceived situations, but not of arbitrary situations. Some might see this as a weakness in LP (and in first-order

logic); others might see it as injunction against speaking in the way we do in natural language, of arbitrary scenes and situations.

JON BARWISE

Stanford University
University of Wisconsin/Madison

QUANTUM MYSTERIES FOR ANYONE

We often discussed his notions on objective reality. I recall that during one walk Einstein suddenly stopped, turned to me and asked whether I really believed that the moon exists only when I look at it.

A. Pais[1]

As O. Stern said recently, one should no more rack one's brain about the problem of whether something one cannot know anything about exists all the same, than about the ancient question of how many angels are able to sit on the point of a needle. But it seems to me that Einstein's questions are ultimately always of this kind.

W. Pauli[2]

PAULI and Einstein were both wrong. The questions with which Einstein attacked the quantum theory do have answers; but they are not the answers Einstein expected them to have. We now know that the moon is demonstrably not there when nobody looks.

The impact of this discovery on philosophy may have been blunted by the way in which it is conventionally stated, which leaves it fully accessible only to those with a working knowledge of quantum mechanics. I hope to remove that barrier by describing this remarkable aspect of nature in a way that presupposes no background whatever in the quantum theory or, for that matter, in classical physics either. I shall describe a piece of machinery that presents without any distortion one of the most strikingly peculiar features of the atomic world. No formal training in physics or mathematics is needed to grasp and ponder the extraordinary behavior of the device; it is only necessary to follow a simple counting argument on the level of a newspaper braintwister.

Being a physicist, and not a philosopher, I aim only to bring home some strange and simple facts which might raise issues philosophers would be interested in addressing. I shall try, perhaps

[1] *Reviews of Modern Physics*, LI, 863 (1979): 907.

[2] From a 1954 letter to M. Born, in *The Born-Einstein Letters* (New York: Walker, 1971), p. 223.

0022-362X/81/7807/0397$01.20